Earth Science Technology Program (ESTP)

Presentation to ESSAAC

May 7-8, 2002

"The Committee requests that a technology assessment report be given during the next meeting, covering the specifics of future critical path technologies that are needed for the Enterprise to complete its science agenda."

George J. Komar
Program Manager

Deriving Measurement Requirements from the Research Strategy (with Science Themes)

Variability

- **GWEC** — Precipitation, evaporation & cycling of water changing?
- **O&I** — Global ocean circulation varying?
- **BIO** — Global ecosystems changing?
- **CHEM** — Stratospheric ozone changing?
- **O&I** — Ice cover mass changing?
- **SE** — Motions of Earth & interior processes?

Forcing

- **CHEM** — Atmospheric constituents & solar radiation on climate?
- **BIO** — Changes in land cover & land use?
- **SE** — Surface transformation?

Response

- **GWEC** — Clouds & surface hydrological processes on climate?
- **BIO** — Ecosystem responses & affects on global carbon cycle?
- **O&I** — Changes in global ocean circulation?
- **CHEM** — Stratospheric trace constituent responses?
- **O&I** — Sea level affected by climate change?
- **CHEM** — Pollution effects?

Consequence

- **GWEC** — Weather variation related to climate variation?
- **BIO** — Consequences in land cover & land use?
- **BIO** — Coastal region change?

Prediction

- **GWEC, Model** — Weather forecasting improvement?
- **Model** — Transient climate variations?
- **Model** — Trends in long-term climate?
- **Model** — Future atmospheric chemical impacts?
- **BIO, Model** — Future concentrations of carbon dioxide and methane?

Legend

- Red: Requires both systematic & exploratory satellites
- Green: Requires systematic satellite observations
- Blue: Requires exploratory satellite observations
- Orange: Requires pre-operational and/or systematic/expl
- Purple: Use available/new observations in better models

Technology Capability for the Research Strategy Needs

Variability	Forcing	Response	Consequence	Prediction
Precip Radar, Radiometer, Large Antenna, Very Low Freq. Radar, On-board Processing	Active Optical, Interferometry, Interoperable Data Models	Radiometry, SAR, Interferometric SAR, On-board Processing/Data Compression/Storage	Precip Radar, Data Mining, Fusion	Real-time Data Assimilation, Interoperable Data Models
Precision Altimetry, Vector Wind, Active/Passive Microwave	Imaging Spectrometry, Hyperspectral, Low Freq. Radar, Data Mining, Fusion	Active Optical, Data Distribution, Mining, Fusion	Hyperspectral, Topography, Data Distribution, Mining, Fusion	Climate Modeling, Data Visualization
Imaging Spectroscopy, Dual Freq. Radar, Data Mining, Fusion	Hyperspectral Imaging, Thermal, Ob-board Processing/Data Compression/Storage, Fusion	SAR, On-board Processing/Data Compression/Storage, Mining, Visualization	Multispectral Radiometry, Data Mining	Long-term Climate Modeling, Data Mining, Fusion
UV-IR Spectrography & Imaging, Lidar		UV-IR Spectrography & Imaging, Spectrometry, On-board Processing/Data Compression/Storage		Atmospheric Constituent Modeling
Dual Freq. SAR, Lidar Altimetry, Data Mining		SAR Interferometry, GPS, Data Visualization		Carbon Cycle Modeling, Data Visualization
Gravity Gradiometer, Magnetometer		Lidar, Passive Radiometry, Data Visualization		

The Path from Measurement Needs to Technology Capability

13 Meetings/Workshops (to engage the community)
- Wide Community Involvement
- Distributed across Academia, Industry and other Govt. Organizations

↓

Capability Needs for Science, Applications and Technology (CN-SAT)
- Capture Technology Requirements and track in database

↓

Integrated Technology Development Plan
- Plan for what technology will be developed

Focus for Technology Solicitations

NRA Solicitations	Focus
NMP EO-1 (Space Validation) '96 $192M	Validate technologies contributing to the cost reduction and increased capabilities for future land imaging missions. (Landsat data)
IIP Round 1 (Instruments) '98 27 for $39M	Open and unconstrained; covering active and passive optical and active and passive microwave instruments
NMP EO-3 (Space Validation) '98 $105M	Validate technologies contributing to the cost reduction and increased capabilities for future weather forecasting. (future GOES)
ATI Component Technology (ACT Round 1) '99 23 for $17M	Core instrument technology; covering active and passive optical, and active and passive microwave instrument components
AIST Round 1 (Info Systems) '99 30 for $26M	On-board space-based information systems applications including data processing, organization, analysis, storage, and transmission; intelligent sensor and platform control; and network configuration.
IIP Round 2 (Instruments) '01 11 for $30M	Microwave radiometry, radar, laser/lidar instruments
ACT Round 2 (Components) '02 $12M max for 3 yrs	Antenna, electronics, detectors, and optics components
AIST Round 2 / IIP Round 3 $18M max for 3 yrs / $25M max for 3 yrs	In Process for FY 03

Distributed FY 01-02 Technology Investments

GSFC (27)

IIP	7
ATI	6
AIST	2
Proto	7
TM	5

JPL (35)

IIP	13
ATI	7
AIST	8
Proto	1
TM	6

LaRC (12)

IIP	3
ATI	2
AIST	1
TM	6

Other NASA Centers (4)

ARC (AIST -1; Proto - 1)
GRC (AIST - 1; Battery - 1)

IIP:	**38**
ATI:	**23**
AIST:	**30**
Prototyping:	**27**
Tech. Maturation:	**30**
Cong. Initiative:	**1**
Total Awards:	**148**

NOAA (1)

IIP - 1

National Labs (7)

Aerospace Corporation (ATI - 1)
DOE PNNL (Proto - 1)
JHU/Applied Physics Laboratories (IIP - 2)
Draper Laboratories (AIST - 1)
Naval Research Laboratories (AIST -1)
Sandia National Laboratories (IIP - 1)

ESTO

Academia (30)

Clemson University (Proto - 1)
Colorado State U. (IIP - 1)
George Mason U. (Proto -2; TM - 1)
George Washington U. (TM - 1)
Harvard University (IIP-1)
Howard University (AIST - 1)
Johns Hopkins University (ATI -1; TM - 1)
Morgan State U. (TM - 1)
Ohio State University (IIP-1; Proto - 1)
Ohio University (AIST - 1)
Rutgers University (IIP - 1)
Stanford University (ATI - 1)
UAH (AIST -2; Proto - 1; TM - 1)
U. of Arizona (IIP -2; AIST - 1)
U. of California, Berkeley (IIP - 1)
U. of Kansas (IIP - 1; AIST -1)
U. of Missouri (TM - 1)
U. of Virginia (Proto - 1)
U. of Washington (AIST - 2)

Small Corps. (17)

AstroPower, Inc. (TM - 1)
ElectroEnergy, Inc. (TM - 1)
EcoLogic (Proto - 1)
Fibertek, Inc. (ATI - 1)
GS&T, Inc. (Proto - 1; TM - 2)
Maxwell Technologies, Inc. (AIST - 1)
Pico Dyne, Inc. (AIST -1)
Polatomic (IIP - 1)
QSS, Inc. (AIST - 1; Proto -1)
SGT (Proto - 2)
Spaceborne, Inc. (ATI - 1)
Syagen Technology, Inc. (ATI -1)
Various Vendors (TM - 1)

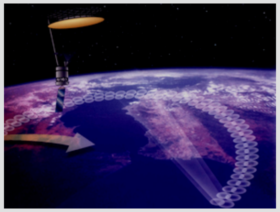
Large Corps. (15)

BAE Systems (IIP-1)
Ball Aerospace (ATI - 2)
CSC (Proto - 1)
ITT Industries (AIST - 1; TM - 1)
Lockheed Martin (AIST - 1; Proto -1)
Orbital Sciences Corp. (IIP - 1)
RITSS (Proto - 4)
SAIC (AIST - 1)
TRW (AIST -1)

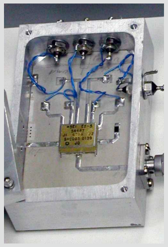
Technology Success Stories

- 6 ESSP-3 Proposals based on IIP Instruments
  - Delay Doppler Phase (D2P) Radar Altimeter
    - ABYSS (ocean floor)
  - Low Mass, Low Power Radar (OSIRIS)
    - HYDROS (soil moisture)
  - Ultra Stable Microwave Radiometer (USMR)
    - AQUARIUS (sea surface salinity)
  - Gas and Aerosol Monitoring Sensorcraft (GAMS)
  - Integrated UV-IR Spectrograph and Imager (SCH_2OO_3NERS)
  - Wide Field Imaging Spectrometer (WFIS)
- 3 AIST projects related to Open GIS Consortium (OGC) for access to Earth science data
  - NASA Web GIS Server Web Coverage Client EOSDIS Data Pools
  - Sensor Modeling Language
  - OGC Service Model CEOS Data Interoperability

D2P Radar Altimeter flew on NRL P-3 over Greenland



OSIRIS System configuration

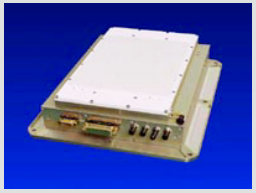


USMR: Pin diode switch assembly

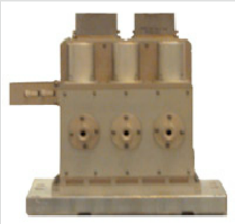
Success Story: New Millennium Program (NMP)

EO-1: Validation of 9 Breakthrough Technologies

- Advanced Land Imager: reduces costs for future missions
- Hyperion (hyperspectral imager): enables new earth science capabilities

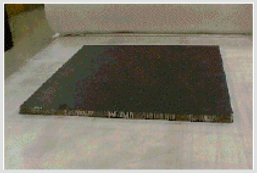


X-Band Phased Array Antenna

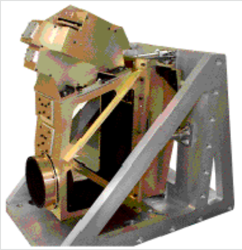


Leisa Atmospheric Corrector

Advanced Land Imager



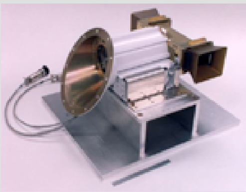
Carbon-Carbon Radiator



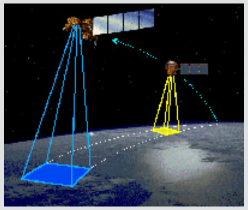
Hyperion

Wideband Advanced Recorder/Processor

Lightweight Flexible Solar Array



Pulsed Plasma Thruster

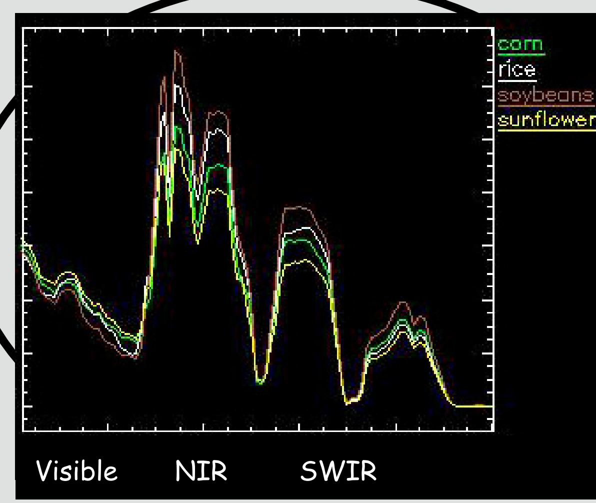


Enhanced Formation Flying

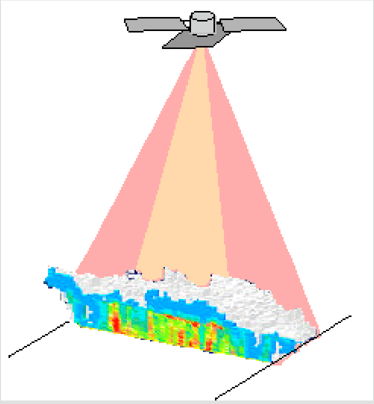
EO-1 Hyperion Distinguishes Crop Types

Detailed spectra allow greater potential for plant type identification than does LandSat

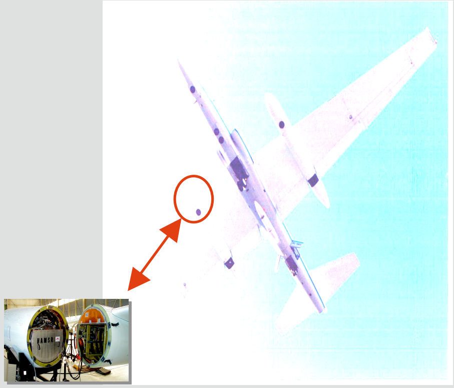
Green - Corn
White - Rice
Brown - Soybean
Yellow- Sunflower



Technology Infusion Success Stories



PR-2

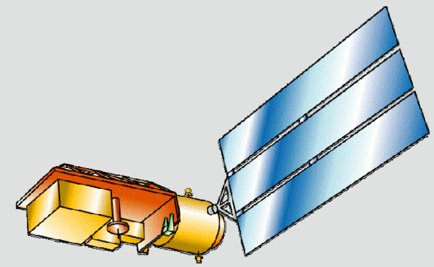


HAMSR in ER-2 Wing Pod

• *We have infused technology into the CAMEX-4, a multi-agency field campaign to study hurricanes in August 2001*.

- Second Generation Precipitation Radar, PR-2 (airborne) flew on the DC-8.
- High Altitude MMIC Sounding Radiometer (HAMSR) measuring temperature, water vapor and clouds flew on the NASA ER-2.

NPP In-Situ User Terminal

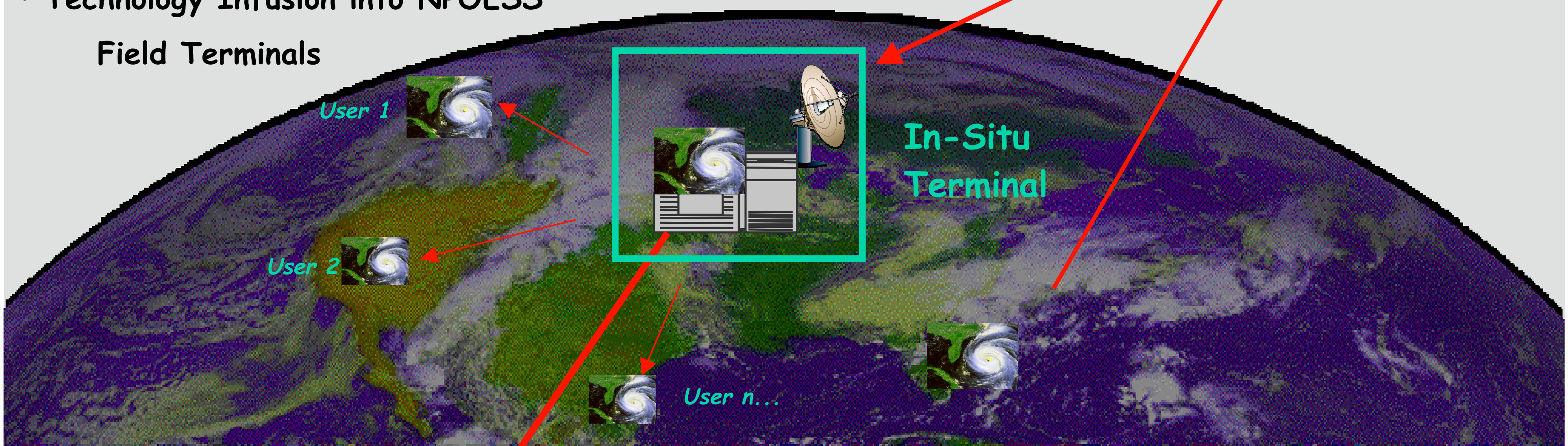


NPP Satellite

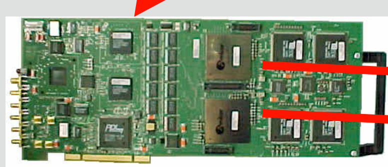
__Features__:

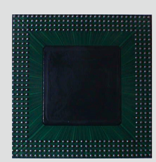
- High rate front end
  - RF processing, CCSDS packet processing, Data capture
- Data processing and archive environment
  - Level 0, 1, & EDRs, Ancillary Data, Algorithms, Calibration tables
- Technology Infusion into NPOESS

  Field Terminals



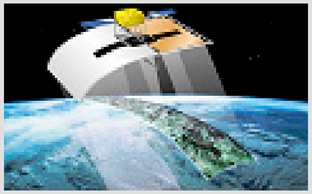
NPP Digital
Receiver Board

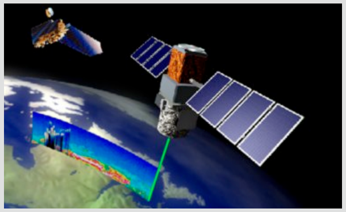




ESTO Digital De-Modulator
ASIC

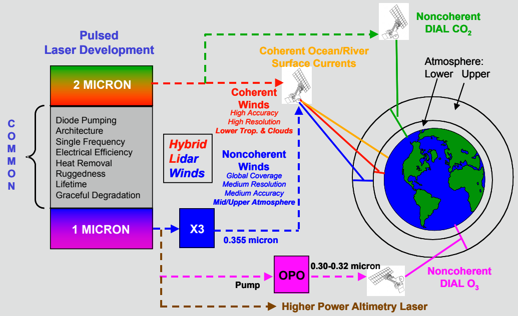
Current Technology Challenges





Large Deployables

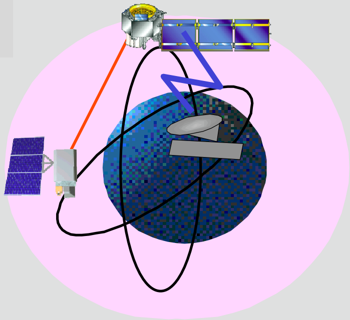
Laser/Lidar



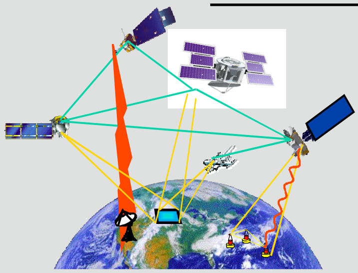
Fill Technology Capability Gaps

Optical Comm

Communication



Information Knowledge Capture



Intelligent Distributed Systems

Dissemination of Knowledge

More Work to be Done … Getting the Red Out

Variability	Forcing	Response	Consequence	Prediction
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Gravity Gradiometer, Magnetometer		Lidar, Passive Radiometry, Data Visualization		

Summary

Critical Technologies Enabling Science

- Lightweight Microwave Radiometry to enable Global Precipitation Measurement
- Advanced Low Mass, Low Power Radar to enable Soil Moisture Measurement
- Delay Doppler Radar Altimetry to enable Ocean Bathymetry Measurement

Challenges to Enable Future Science

- Laser/Lidar technology to enable atmospheric science measurements
- Large Deployables to enable future weather/climate/natural hazards measurements
- Intelligent Distributed Systems using optical communication, on-board reprogrammable processors, autonomous network control, data compression, high density storage
- Information Knowledge Capture through 3-D Visualization, holographic memory and seamlessly linked models.